

Friday, February 19, 2021

PTJ North

PLANETARY SCALE OCEANIC CO₂ MITIGATION SUMMARY TOPIC REPORT

Introduction

This report updates in a modest way my original work published in early 2021. I hope it clarifies my logic and limits I have placed on myself. I call those limits my guardrails.

Finding the way to remove and stabilize dissolved CO₂ at a consistent and safe level from the world ocean represents an enormous opportunity to stabilize and reverse the rapid degradation of the world ocean's biota that cannot be ignored. Without a healthy world ocean biota all terrestrial life would rapidly end. This problem of our creation represents an existential threat.

It also represents a unique climate change carbon removal opportunity as well. Said carbon removal opportunity is certainly large enough to "budge the needle" and could largely offset the melting of arctic permafrost and its release of organic carbon into the atmosphere which is an emerging major contributor to both climate change and global warming.

I propose to remove and stabilize or "fixate" that excess oceanic dissolved CO₂ in two ways. Both, taken together would largely resolve the problem on an ongoing basis. If only one is chosen, then that ongoing problem resolution could be in doubt or be, at minimum, much more costly:

One: Mine the methane clathrate deposits that exist in the oceanic subsurface and use the recovered methane to make products for human use (fuel, plastics etc). As a function of solution mining the methane clathrate, we can simultaneously reform the former methane clathrate deposits into carbon dioxide (CO₂) clathrates (not new science btw) that fixes that CO₂ into a stable form and remove it from the carbon cycle.

Two: Add a simple combination of very finely ground lime (CaO) and calcium carbonate (CaCO₃) into limited areas of the ocean and induce a form of cascade reaction via nucleation of a coarse, granular limestone that would settle readily onto the ocean floor as a stable deposit with no harm to the surrounding biota.

Both methods will work. Both will require well-resourced teams to prove up and scale up. **The profit potential from the first method is enormous – very likely on**

the order of $\$1 \times 10^{14}$ or more spread over a 20 – 30-year span. A very small portion of the profit from this work could be used to fund the other program which is why I developed it despite its risks. The other is best dealt with at the governmental level and would cost a very small fraction of the first method in my estimation. Those fractions and their definition should be left to a well-financed team and not me alone.

If oceanic CO₂ removal by alkalinity enhance is only pursued, then I have provided a likely funding model as an addendum to this report.

The scale of the overall problem is enormous. I refer to that scale as planetary engineering. Think at that scale, make considered decisions and a plan and you will conquer the problem.

By others:

“As the planet's most abundant resource, seawater accounts for 70% of the Earth's surface, contributing to various natural cycles in the Earth ecosystem. One representative cycle is the water cycle, in which solar energy evaporates seawater to separate salts and water vapor, producing fresh water [1]. Another significant cycle is the carbon cycle, which maintains the atmospheric carbon dioxide (CO₂) level by capturing the gas in seawater and forming carbonated materials such as CaCO₃ and CaMg (CO₃)₂ [2]. However, the sharp increase in the world population and the use of fossil fuels have caused water scarcity [3–5] and the elevation of the CO₂ concentration in the atmosphere.

According to the Worldwatch Institute, an estimated 1.8 billion people will reside in complete water scarcity regions in 2025, while almost 50% of the world's population will suffer from water stresses [6]. Additionally, the Earth is naturally able to process 14 billion tons of CO₂ per year by diffusing CO₂ into water or by photosynthesis by green plants [7]. However, according to the report [7], the CO₂ emissions in 2050 are predicted to be 62 billion tons per year, which is more than four times the level that the Earth can handle per year.”

Another perspective:

"The release of methane from clathrates (sub-ocean floor deposits – this author) to the atmosphere is one of the main reasons for the periodic warming of climate.

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The relationship between the concentration of methane in the atmosphere (estimated from the research on ice cores) and atmospheric temperature over the last 420 000 years has been noted by Wuebbles and Hayhoe [8]. They connected the synchronic changes in temperature and the concentrations of methane in the glacial and interglacial periods with alternating periods of destabilization and stability of methane clathrate deposits identified based on geological data recording varying participation of individual carbon isotopes in the sediment."

So, what will happen in an anthropogenic climate warming situation like the one we are causing? Will it only be similar in scope to the above statement? It will be something far worse I suspect.

It's time to mine this resource and use it - rather than lose it and suffer yet more hazard. You've got to remember that I am not a tree hugger but rather a pragmatist.

This author believe he has found (circa August 2019) a unique and practical way to successfully mine this enormous hydrocarbon resource for what will very likely be least cost and least risk. This way is outlined in the "Notes" section at the end of this simple updated summary from the original report published in August 2019.

Background

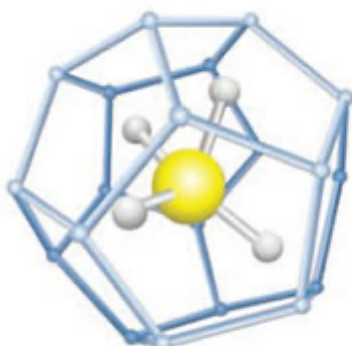
As is normal for this author, I have found others who can state the broad situation better than I can do so. I have singularly focused on the methane hydrate mining solution. The other method of CO2 removal largely explains itself in its' dedicated "Notes" section.

Please see below:

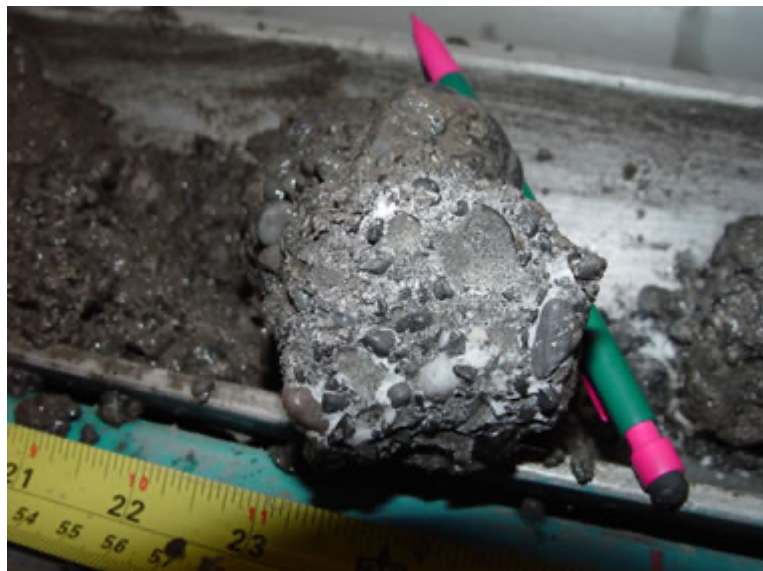
Methane Hydrate

The world's largest natural gas resource is trapped beneath permafrost and ocean sediments.

Article by: [Hobart M. King](#), Ph.D., RPG



Methane hydrate: On the left above is a ball-and-stick model of methane hydrate showing the central methane molecule surrounded by a "cage" of water molecules. Other hydrocarbon molecules such as pentane and ethane can occupy the central position in this structure. (United States Department of Energy image). On the right is a burning specimen of methane hydrate ice (United States Geological Survey image).



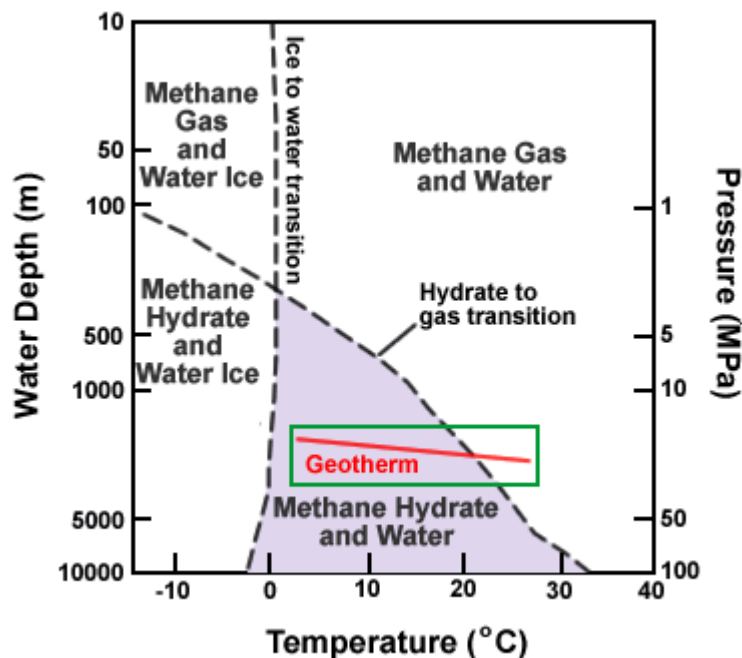
Methane hydrate "cement" in conglomerate: This photo shows a core sample of the methane hydrate zone in the Mallik Test Well. This well penetrates permafrost deposits in Canada's Mackenzie River Delta area. This portion of the core shows gravels cemented into a "conglomerate" by methane hydrate ice. Click to [enlarge image](#).

The Next Energy "Game Changer"?

As [natural gas](#) from [shale](#) becomes a global energy "game changer," oil and gas researchers are working to develop new technologies to produce natural gas from methane hydrate deposits. This research is important because methane hydrate deposits are believed to be a larger hydrocarbon

resource than all of the world's oil, natural gas and [coal](#) resources combined. [1] If these deposits can be efficiently and economically developed, methane hydrate could become the next energy game changer.

Enormous amounts of methane hydrate have been found beneath Arctic permafrost, beneath Antarctic ice, and in sedimentary deposits along continental margins worldwide. In some parts of the world, they are much closer to high-population areas than any natural gas field. These nearby deposits might allow countries that currently import natural gas to become self-sufficient. The current challenge is to inventory this resource and find safe, economical ways to develop it.



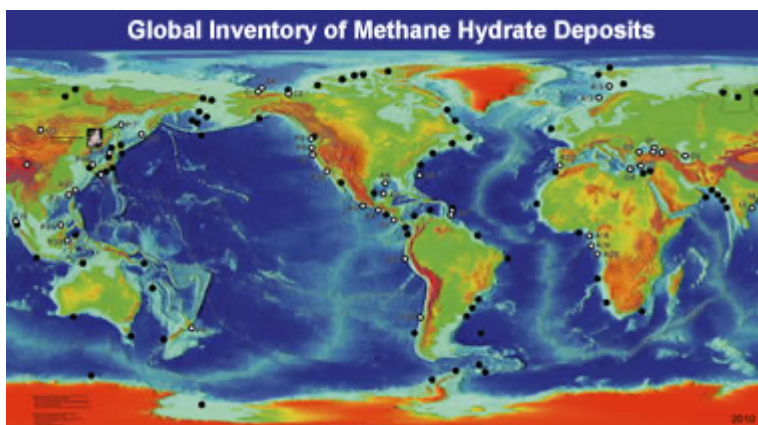
Methane hydrate stability chart: This phase diagram shows water depth (pressure) on the vertical axis and temperature on the horizontal axis. The dashed lines separate stability fields of water, water ice, gas, and gas hydrate. The line labeled "hydrate to gas transition" is significant. Conditions for the formation of methane hydrate occur below this line. Above this line methane hydrate will not form. The red line traces a geotherm (the change of temperature with depth at a specific location). Note how, as depth increases, the geotherm crosses the hydrate to gas transition line. This means that gas hydrate in sediments usually overlies free gas. Graph modified after NOAA. [4]

What is Methane Hydrate?

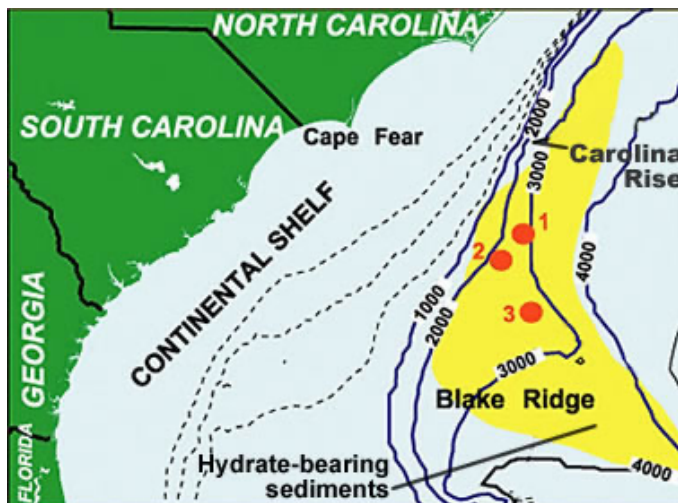
Methane hydrate is a crystalline solid that consists of a methane molecule surrounded by a cage of interlocking water molecules (see image at the top of this page). Methane hydrate is an ["ice"](#) that only occurs naturally in subsurface deposits where temperature and pressure conditions are favorable for its formation. These conditions are illustrated in the phase diagram on this page.

If the ice is removed from this temperature/pressure environment, it becomes unstable. For this reason, methane hydrate deposits are difficult to study. They cannot be drilled and cored for study like other subsurface materials because as they are brought to the surface, the pressure is reduced, and the temperature rises. This causes the ice to melt and the methane to escape.

Several other names are commonly used for methane hydrate. These include methane clathrate, hydromethane, methane ice, fire ice, natural gas hydrate, and gas hydrate. Most methane hydrate deposits also contain small amounts of other hydrocarbon hydrates. These include propane hydrate and ethane hydrate.



Methane hydrate map: This map is a generalized version of locations in the USGS global inventory of natural gas hydrate occurrence database. [2]

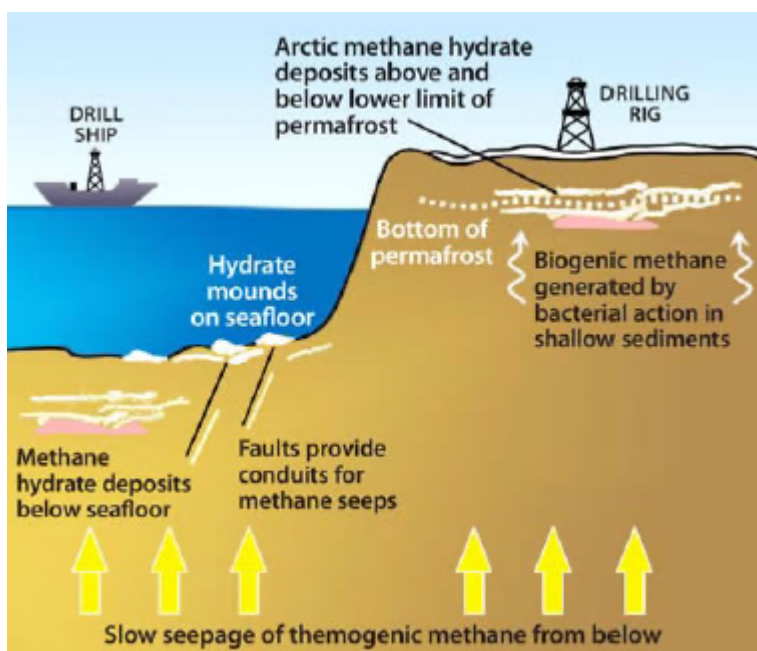


Gas hydrate map: One of the most extensively studied gas hydrate deposits is Blake Ridge, offshore North Carolina, and South Carolina. Challenges of producing methane from this deposit are the high clay content and the low methane concentration. [3] This map is an example of the proximity of continental margin deposits to potential natural gas markets. Image by NOAA. [4]

USGS Gas Hydrates Lab: This video takes you on a visit to the USGS Gas Hydrates Lab where researchers conduct experiments on samples of gas hydrates collected from polar and continental margin areas. They also create synthetic gas hydrates and conduct experiments to determine their chemical and physical properties.

Where Are the Methane Hydrate Deposits?

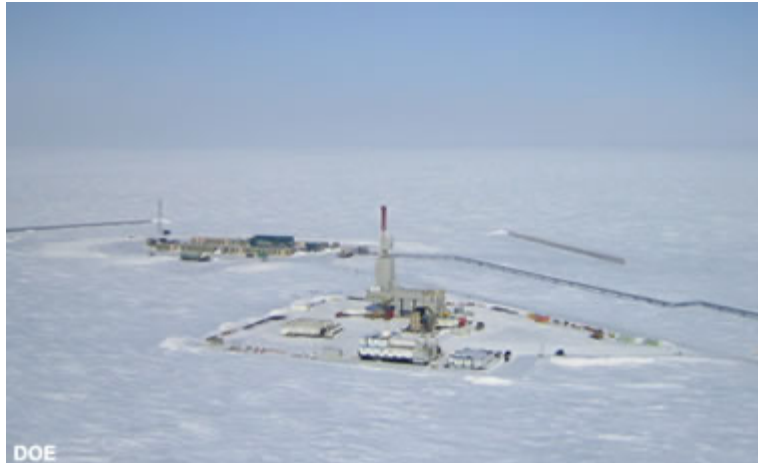
Four Earth environments have the temperature and pressure conditions suitable for the formation and stability of methane hydrate. These are: 1) sediment and [sedimentary rock](#) units below [Arctic](#) permafrost; 2) sedimentary deposits along continental margins; 3) deep-water sediments of inland lakes and seas; and, 4) under [Antarctic ice](#). [10]. With the exception of the Antarctic deposits, methane hydrate accumulations are not very deep below Earth's surface. In most situations the methane hydrate is within a few hundred meters of the sediment surface.



Methane hydrate deposit models: Deposit models for methane hydrate deposits at continental margins and under permafrost. [7]

In these environments' methane hydrate occurs in the sediment as layers, nodules, and intergranular cements. The deposits are often so dense and laterally persistent that they create an impermeable layer that traps natural gas moving upwards from below.

In 2008, the United States Geological Survey estimated the total undiscovered gas hydrate resource for the Alaska North Slope area. They estimate that the total undiscovered natural gas resource in the form of gas hydrate ranges between 25.2 and 157.8 trillion cubic feet. Because very few wells have been drilled through the gas hydrate accumulations, the estimates have a very high level of uncertainty. [5]



Gas hydrate well: Ignik Sikumi #1 gas hydrate well on the Alaska North Slope. A USGS gas hydrate resource assessment determined that the North Slope has an extensive gas hydrate resource trapped below permafrost. Department of Energy photo.

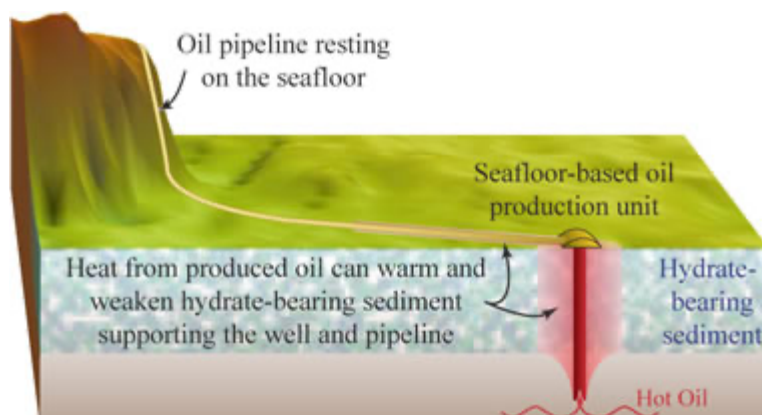
Ignik Sikumi: This video takes you on a visit to the Ignik Sikumi gas hydrate field trial, a well on Alaska's North Slope that produced natural gas from gas hydrates below permafrost. The accomplishment made here was to liberate the methane by replacing it with carbon dioxide - without melting the gas hydrate.

Where is Methane Hydrate Produced Today?

To date there has been no large-scale commercial methane production from gas hydrate deposits. All of the production has either been small scale or experimental.

In early 2012, a joint project between the United States and Japan produced a steady flow of methane by injecting carbon dioxide into the methane hydrate accumulation. The carbon dioxide replaced the methane in the hydrate structure and liberated the methane to flow to the surface. This test was significant because it allowed the production of methane without the instabilities associated with a melting gas hydrate. [6]

The most likely methane hydrate deposits to be selected for first development will have the following characteristics: 1) high concentrations of hydrate; 2) reservoir rocks with high permeability; and 3) locations where there is an existing infrastructure. [7] Deposits meeting these characteristics will likely be located on the Alaska North Slope or in northern Russia.



Gas hydrate melting: When oil wells are drilled through hydrate-bearing sediments, the warm temperature of the oil moving up through the frozen hydrate zone can cause melting. This can result in well failure. Warm pipelines running over frozen hydrate outcrops is also a hazard. [8] USGS image.

Methane Hydrate Hazards

Methane hydrates are sensitive sediments. They can rapidly dissociate with an increase in temperature or a decrease in pressure. This dissociation produces free methane and water. The conversion of a solid sediment into liquids and gases will create a loss of support and shear strength. These can cause submarine slumping, landslides, or subsidence that can damage production equipment and pipelines. [7]

Methane is a powerful greenhouse gas. Warmer Arctic temperatures could result in gradual melting of gas hydrates below permafrost. Warming oceans could cause gradual melting of gas hydrates near the sediment-water interface. Although many news reports have presented this as a potential catastrophe, USGS research has determined that gas hydrates are currently contributing to total atmospheric methane and that a catastrophic melting of unstable hydrate deposits is unlikely to send large amounts of methane into the atmosphere. [9]

Did You Know? Methane hydrate has a very high concentration of methane. If you melt a one cubic meter block of methane hydrate, about 160 cubic meters of gaseous methane will be released.

Methane Hydrate References

[1] [USGS Gas Hydrates Lab](#): Stephen Wessells, Laura Stern, Steve Kirby; United States Geological Survey Multimedia Gallery Video, 2012.

[2] **A Global Inventory of Natural Gas Hydrate Occurrence**: Keith A. Kvenvolden and Thomas D. Lorenson, Pacific Coastal & Marine Science Center, United States Geological

Survey.

[3] [Natural Gas Hydrates: A Review](#): Timothy S. Collett, Arthur H. Johnson, Camelia C. Knapp, Ray Boswell; Natural gas hydrates--Energy resource potential and associated geologic hazards: AAPG Memoir 89, p. 146-219, 2009.

[4] [Gas Hydrates Offshore Southeastern United States](#): Carolyn Ruppel, Georgia Institute of Technology, NOAA Ocean Explorer website, last accessed November 2016.

[5] **Assessment of Gas Hydrate Resources on the North Slope, Alaska, 2008**: United States Geological Survey, Fact Sheet 2008-3073, October 2008.

[6] [U.S. and Japan Complete Successful Field Trial of Methane Hydrate Production Technologies](#): United States Department of Energy press release, May 2, 2012.

[7] [Energy Resource Potential of Methane Hydrate](#): An introduction to the science and energy potential of a unique resource; publication by the National Energy Technology Laboratory, United States Department of Energy, February 2011.

[8] [Pure phase thermal property results: sI Methane Hydrate](#): Woods Hole Science Center, United States Geological Survey, 2007.

[9] [Gas Hydrates and Climate Warming](#) - Why a Methane Catastrophe Is Unlikely: Carolyn Ruppel and Diane Noserale, United States Geological Survey, Sound Waves Newsletter, May/June 2012.

[10] [Study suggests large methane reservoirs beneath Antarctic ice sheet](#): Tim Stephens, press release, University of California Santa Cruz, August 29, 2012.

Enormous Potential

Although methane hydrate accumulations are in difficult environments and present numerous technical challenges, they are widely distributed and the largest source of hydrocarbons on Earth. A variety of technologies could be developed to produce them using pressure reduction, ion exchange, and other processes that take advantage of their unique chemical and physical properties. The United States, Canada, Japan, and India all have vigorous research programs working to discover viable technologies for producing gas hydrates. Methane hydrate will likely play an important role in our future energy mix."

Solution Mining Validation

Validating or rejecting the solution mining concept as originally conceived by this author in August 2019 serves as the basis for a prior art statement.

The following statement by others does so:

"In a gas exchange method (what I call solution mining - author), carbon dioxide is introduced into the clathrate deposit in a gaseous form or as an aqueous solution. Methane occupies small and large cages in the clathrate structure, CO₂ occupies only large cages, forcing CH₄ out of them. It is estimated that in this way, without causing disintegration of a clathrate deposit, about 64% of the methane present in the deposit may be extracted. The reaction of CO₂ clathrate formation is exothermic – formation heat is 57.9 kJ/mol. The disintegration of methane clathrate is an endothermic process – its individual dissociation heat is 54.5 kJ/mol, and thus it is lower than the formation heat of CO₂ clathrate. As a result, the whole exchange process is exothermic [20]. Thus, the method is based on heating and decay of methane clathrates by the heat released during formation of carbon dioxide clathrates after its injection into the deposit of methane clathrates."

Notes with IP capture

Methane Hydrate Mining Notes

1. Said deposits are widespread and seemingly accessible for conventional light hydrocarbon drilling access - that is very wrong.
2. Deposits are widespread but are not easily accessible due to their varied depositional environments.
3. Terrestrial deposits underlie permafrost and are normally intercalated with them.
4. Terrestrial deposits are metastable and very vulnerable to climate change warming with sudden and violent offgassing being observed.
5. Accordingly, terrestrial deposits unless deep (<100M) with a structural "cap" or structure in place (rare btw) should not be mined.
6. Proposed mining as per tar sands practices is not practical and would be very unstable and hazardous.

7. Additionally, warming terrestrial deposits will undergo rapid methanogenesis of surrounding carbon sources exacerbating the offgassing issue - meaning a wellpad or similar will not be mechanically stable or necessarily accessible or profitable for any meaningful length of time (IP point).
8. Marine margin deposits are generally accessible but have the same limitations as terrestrial deposits.
9. Deep water deposits (<1000M) offer the best opportunity for successful mining with least hazard (IP point).
10. Deep water deposits also are the most stable if associated with structural traps.
11. Deep water deposits offer the opportunity to use solution mining to free methane and associated light hydrocarbons from its clathrate matrix on a preferential basis (IP point).
12. Climate change related warming will not be a problem for deep water deposits unless marine circulation patterns are radically disturbed which is unlikely.
13. Deep water "open" deposits do exist but should not be mined to prevent or preclude the high probability of underlying free methane and associated hydrocarbons and carbon dioxide from violently offgassing into the water column (IP point).
14. Deep water open deposits would theoretically offer drag bucket mining as an option. The previous statement should preclude this in practice (IP point).
15. Deep water solution mining using supercritical liquid gases such as CO₂ or N₂ will work (IP point).
16. Not all supercritical or in-situ placed solid, or liquid or gases will work (IP point).
17. The preferential gases of choice for deep water solution mining should be nitrogen and carbon dioxide (IP point).
18. Trace amounts of other gases is acceptable for this application (IP point).
19. Propane or butane or pentane or other similar molecules could be used but will likely not be economical (IP point).
20. Deep water EOR techniques are not applicable due to intercalation (IP point).
21. Wellbore casings are a requirement for this application (IP point).

22. Annulus recovery of off gassed methane and other light hydrocarbons is not required (IP point).
23. Specialty organic chemistry for this application is not required (IP point).
24. Given the likely operating conditions for these deep-water hydrate deposits the use of liquid supercritical gases as solution mining constituents is desirable (IP point).
25. All pipeline materials must be high alloy ferrous materials suitable for the application of drilling and production which may also mean the production of supercritical hot mixed liquids or fluids or phases of gases of methane, nitrogen, water, and an array of light hydrocarbons (IP point).
26. Extraction pipeline (s) including gathering systems must be sized and insulated to preclude solid phase gas blockages (IP point).
27. Pigging of deep-water pipelines will not be practical or useful.
28. Local supply of supercritical fluidic gases is a requirement (IP point).
29. Shipboard, drilling platform or production platform must have Air Separation Unit (ASU) capacity otherwise known as air mining capabilities sufficient to include compression, combustion, heat recovery, distillation, fractionation, and molecular sieve capabilities sufficient for the application (IP point).
30. Recovered methane and other associated light hydrocarbons can be transferred on shore as warm or hot supercritical fluids for further fractionation or separation and packaging (IP point).
31. On board, whether ship or platform, LOX or gaseous O₂ and LH₂ or gaseous hydrogen, may be combusted using an expanding gas turbine for both power and heat (IP point).
32. Separated and spatially separated injection and extraction wells will be required (IP point).
33. Liquid supercritical nitrogen must first be injected to facilitate a "temporary" trap or cap above the deposit or liquid or supercritical gaseous nitrogen or carbon dioxide (IP point).
34. Inerting the process of extraction for safety and deposit stability with a nitrogen cap for deep water methane and associated light hydrocarbons extraction is desirable (IP point).
35. Enhancing the process of extraction for safety for shallow but still deep-water deposit stabilization with a carbon dioxide cap for deep water

- methane and associated light hydrocarbons extraction is also desirable (IP point).
36. In situ replacement of carbon dioxide but not nitrogen within a reformed hydrate or clathrate matrix is desirable (IP point – could be contested).
 37. Mitigating climate change by "fixing" solid phase carbon dioxide in perpetuity within such a deposit is desirable (IP point).
 38. Mining or removing said deposits methane and associated light hydrocarbons is desirable from an onshore energy generation and refining perspective (IP point).
 39. Offshore distillation within its Air Separation Unit (ASU) will generate large volumes of fresh or low salinity water suitable for on board potable consumption (IP point).
 40. Separated liquid or gaseous phase high salinity water may be safely discharged to either the atmosphere or ocean without consequence (IP point).
 41. Injection wellbores must be properly sized for the application (solution mining of a metastable substance which means 2 - 3" or less) which means "small". Extraction wells can be larger bore (6 - 8") but must be grid distributed just as the injection wells.
 42. This type of solution mining is new - we are not simply dissolving something; we are also allowing a clathrate / hydrate to reform in-situ with different molecules captured in its matrix (CO₂) than beforehand which were methane and other light hydrocarbons (IP point).
 43. Simple solution mining will not yield sustainable results because most deposits are intercalated and if just dissolved with no replacement - the formation or deposit would collapse - possibly catastrophically (IP point).
 44. Do not lease the ASU and other powergen and heat recovery hardware - buy it to keep extraction and primary separation costs to a minimum. (Know how point)
 45. Vertical wells are the best choice in this instance as per solution mining best practices. (Know how point)
 46. Horizontal wells serve no useful purpose. (Know how point)
 47. Fracking would be catastrophic except maybe using liquid CO₂ in limited instances (tight trap). (Know how point-this author)

48. Vertical well may have an injection quill head sufficient to supply the intercalated formation with the liquid supercritical gases for some vertical depth ranging from several feet to possibly as much as 100 feet or more (IP point).
49. Vertical well may have an extraction quill head sufficient to allow the intercalated formations to offgas both liquid supercritical and supercritical gases for some vertical depth ranging from several feet to possibly as much as 100 feet or more (IP point).

CO2 Removal Notes

1. Our global oceans' photic (sunlight infiltrated) zone is saturated with calcium.
2. Non biogenic CO2 is rapidly increasing.
3. Non biogenic CO2 reacts readily with non-biogenic hydrogen sources (sodium bicarbonate - NaHCO_3) to form carbonic acid.
4. Carbonic acid lowers the oceans' pH.
5. Lowering the pH inhibits shell growth and disrupts food chains.
6. Adjusting the oceanic pH toward a normal value will largely restore shell growth and food chains.
7. Oceanic pH is not a simple reaction mechanism.
8. Photic zone reactions differ substantially from benthic (no sunlight infiltration) reactions.
9. Oceanic circulation cells are complex and little understood.
10. Surprisingly wind, sunlight (warmth), depth and salinity seem to be the main drivers.
11. Presence of boron, magnesium, sodium, and potassium inhibit pH driven reactions.
12. Benthic reactions are driven by pressure, temperature, and sulfate levels in the water column at depth and bottom sediments.
13. Availability of organically bound Ca, Mg, P, K may also represent either inhibitors or limit their availability.
14. Research has been largely limited to empirical observations on a sporadic basis with supporting laboratory analysis still being in its infancy.
15. Accordingly, data, while somewhat available, stays largely regionally focused.

16. While some research alludes to possible solutions for this major climate change issue, none definitively state a direction for proper definition, methods, or solutions.
17. PEI modified (polyetherimide) sodium bentonite could be a CO₂ absorption candidate but that does not address permanent fixation which is much more desirable.
18. Benthic bottom sediments are biogenic reducing environments that would release absorbed CO₂ from the bentonite, so not a good idea.
19. It is possible that a photic zone calc / mg / b carbonate in all its polymorphs can be precipitated by addition of a nucleating particulate such as CaCO₃, CaO, Ca(OH)₂ or MgO or Mg(OH)₃.
20. Others are also possible but not explored at this point such as <10-micron CNT' etc.
21. Archaea (a microbe) could also be used to reduce biogenic CO₂ and could then function as nucleators much as coral does.
22. Also, iron salts (NOT ferric chloride) could be used as flocculators (there is such a term) that would agglomerate and precipitate a stable but complex chemically stable compound that would resist benthic sediment reduction as well.
23. A key insight by this author would use airplane (not ship) delivered ultrafine (<10 micron) CaO and CaCO₃ as nucleators; because they are proven at smaller scale but also are widely available and inexpensive (IP point).
24. Air application would be via application along mid ocean ridges allowing rapid mixing, reaction, and precipitation via benthic circulation cells.
25. Photic downwelling zones would also be prime candidates (IP point).
26. Since benthic upwelling locations show the highest CO₂ levels, this makes sense.
27. Initially CaO should be applied to modestly raise the oceans' pH which does dramatically effect CO₂ dissolution and its then precipitation as an insoluble calcium carbonate (IP point).
28. Secondly, then CaCO₃ may be applied to provide a nucleation agent of calcium carbonate which would additionally bind remaining dissolved CO₂ as an insoluble calcium carbonate or its similar insoluble polymorphs (IP point).
29. Some research implies up to 80% reduction in non-biogenic CO₂ levels with application being light but steady over a period of some months (or

- years) in the range of 0.1 - 0.2 mg/l / m² / months would likely accomplish what is needed without adverse biota impact.
30. High altitude application from tote bags discharging from freight planes such as C-130's would be ideal as an application method (IP point).
31. Other more elegant methods likely will be found but none less expensive and none more doable with today's technology.
32. A light "rain" of CaCO₃, its polymorphs etc already happens in the benthic water column.
33. An increase in that "rain" accumulating to some small number of inches for some years will cause no issues at all I suspect, and the dissolved oceanic CO₂ problem is in the past where it belongs.

Addendum:

GLOBAL INFRASTRUCTURE FUNDING MODEL WITH AN INTEGRATED APPROACH FOR GLOBAL CLIMATE CHANGE MITIGATION

Introduction

“Conventional infrastructure funding can’t work for planetary scale projects.”

Infrastructure and its various components, whether it be roads, bridges, dams, telecommunications, and climate change mitigation technologies are required for any society to be successful on a go forward basis. History documents societies that failed by not providing just one of those infrastructure components. Logically, then, all components must be provided on an ongoing basis or government must squarely face the high probability of a catastrophic societal collapse. In a rapidly globalizing world this could be even worse.

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We are citizens of the most globally advanced society with no qualification. Maintaining that qualification requires that we find new ways to fund infrastructure development with input but little monies from government. Why that statement is true is simple. Government rises, falls, and changes through time but the need for useable and sustainable infrastructure never changes.

“Strength lies not in defense but in attack. Attack the problem”

Infrastructure is the backbone of society. Without its continuous development and support society cannot thrive and without it fails badly. Infrastructure therefore requires consistent funding that cannot be stopped or interrupted, or the society will likely fail.

Geoengineering is simply very large-scale projects that are designed to support the resolution of problems caused by other infrastructure needs that support society. Put another way, planetary engineering is the application of technology for the purpose of influencing the global environments of a planet. Its objectives usually involve increasing the habitability of other worlds or mitigating decreases in habitability on Earth. How we design and fund planetary scale projects therefore is needed at least as much as roads, bridges, power grids and a safe potable water supply. It is the subject of this simple paper.

The funding mechanism

Planetary scale infrastructure projects like Direct Air Capture (DAC) carbon removal can be funded from a tax source that has never been exploited. This tax source can be exploited by any government:

Energy Consumption

Energy consumption is now tracked by the U.S. Energy Information Administration which is part of the U.S. Department of Energy. Energy consumption is reported as units of “Btu consumed” and usually in blocks of 1000 Btu.

Funding model

- An energy consumption tax would be collected in \$0.01 / 1000 Btu “blocks” as they are “consumed” or similar.
- A carbon removal award would be paid in \$5.00 / ton “blocks” as they are “removed” or similar.
- The energy consumption tax would equal roughly \$10 Trillion / year if taken on a global basis.
- The carbon removal award would equal roughly \$7 Trillion / year if taken on a global basis.
- The balance of these taxes and awards for energy savings could be spent on more mundane but necessary infrastructure uses such as roads, bridges etc.
- These taxes and awards would be collected daily from local / county / state and federal sources on a global basis.
- This tax “pool” would need to be protected from theft, money laundering, inflation or deflation or appropriation.
- Protection from these would require both cybersecurity and the tax pool funds converted to a “pool” of “coin”. A “coin” would be a unique cryptocurrency encrypted and protected by cybersecurity.
- Cybersecurity would be funded from the “pool”.
- Accruing the value of “coin” in the “pool” is important especially as energy consumption declines.

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- Cryptocurrency for this "pool" would therefore have a finite or fixed number of "coins" available for distribution into qualified projects.
- Accepted and qualified projects would have "coins" converted to USD or other fiat monies to purchase goods and services for the "project".
- Incentives for demonstrable energy savings (some multiple ranging from small to large) would be offered and paid as incremental "coin" for projects that save "energy" both during construction and over its lifetime.
- Said incentives would be paid out both on an anticipated and incremental time basis.

Why Do a funding model?

- Protection would need no oversight except cybercrime prevention.
- Coins increase in value as energy "savings" occur due to the limited number of coins.
- A small number of new coins can be created by "block chain mining" or as incentives realized for energy budget consumption reduction.
- The total value of the coin "pool" would accrue rapidly and likely exceed some very large \$ amount in Yr1 let alone Yr10.
- A sovereign cryptocurrency avoids inflation or deflation risks, acts of God, money laundering, or theft risk etc. Trading between this cryptocurrency and others would be forbidden.
- A founder (whoever that turns out to be) keeps a set minimum number of coins. As coins are "added" or the pool value grows they can be converted to any fiat money either individually or as a block.

Funding uses

- Development of sufficient cybersecurity to ensure the integrity of the pool could be seen as infrastructure. This cybersecurity need not be limited to only uses pertaining to the pool.
- Energy transmission and its related infrastructure could be included or by extension it's cybersecurity and integrity.
- Water treatment and its distribution and food (although food would be a conceptual "stretch").
- Roads, bridges, dams, levees, traffic lights, toll booths etc would be funded.
- Also, nextgen data transmission networks (5G or later) could be funded and maybe should be funded since they seem to be "evergreen".
- Atmospheric carbon stripping via DAC and its permanent removal from the carbon cycle should be included as well. Runaway climate change will cause a global societal collapse far more readily than failing roads or telecommunications.
- This author proposes that planetary scale atmospheric carbon stripping and permanent removal by fixation is the most difficult topic to be considered or acted upon within an infrastructure development framework.
- Alternatively, or also, oceanic CO2 removal could be funded quite easily.